Fatty acid metabolism and deposition in subcutaneous adipose tissue of pasture- and feedlot-finished cattle[1]

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ABSTRACT: An experiment was conducted to evaluate the effects of pasture finishing versus feedlot finishing, over time, on fatty acid metabolism in Angus crossbred steers (n = 24). Ruminal fluid, serum, and adipose tissue biopsies were obtained on d 0, 28, 84, and 140. Pasture forages and diet ingredient samples were obtained at 14-d intervals to determine nutritive value and fatty acid composition. The feedlot diet consisted of corn silage, cracked corn grain, soybean meal, and a vitamin and mineral supplement. The pasture-finished steers grazed sequentially on triticale (× *Triticosecale rimpaui*)/annual ryegrass (*Lolium multiflorum*), alfalfa (*Medicago sativa*)/orchardgrass (*Dactylis glomerata*), and a cool-season grass/legume mixture. The feedlot diet contained an average of 57% of total fatty acids as linoleic acid and 2% as linolenic acid. The pasture forages contained 9% of total fatty acids as linoleic acid and 66% as linolenic acid. Concentrations (% of total fatty acids) of linolenic acid were greater ($P < 0.05$) in ruminal fluid, serum, and adipose tissue of the pasture-finished steers, compared with the feedlot-finished steers. Concentrations (% of total fatty acids) of *cis*-9, *trans*-11 CLA were greater ($P < 0.05$) in adipose tissue of the pasture-finished steers than feedlot-finished steers. Concentrations of *cis*-9, *trans*-11 CLA in adipose tissue declined ($P < 0.05$) in the feedlot-finished steers from d 0 to 28 to 84. In the pasture-finished steers, concentrations of *cis*-9, *trans*-11 CLA in adipose tissue (mg/g of tissue) peaked ($P < 0.05$) on d 28 and remained elevated (ranged from 9.91 to 12.80 mg/g of tissue) throughout the duration of the study. In the pasture-finished steers, linolenic acid concentrations tended to peak ($P = 0.07$) on d 28 and remained elevated (ranged from 0.64 to 0.80% of total fatty acids) throughout the study. It appears that only a short time is needed to alter the n-3 and CLA composition of adipose tissue in cattle finished on pasture.

Key words: beef cattle, conjugated linoleic acid, fatty acid, pasture-finishing, time on feed

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INTRODUCTION

The most common practice of finishing beef cattle in the United States is to feed high-concentrate diets in feedlots. However, there is concern among consumers regarding consumption of beef due to the high fat and SFA content of beef. The USDA recommends that consumption of SFA be limited to less than 10% of caloric intake (USDA, 2005). Consumption of lean meat and avoidance of marbled steaks are recommended (USDA, 2000). Pasture-finished beef may be a healthier product because it has less SFA, greater n-3, and less n-6 PUFA (French et al., 2000; Steen et al., 2003; Realini et al., 2004). Benefits of increased n-3 fatty acid intake include reducing the occurrence of heart disease, reduced hypertension, reduced inflammation, and cholesterol reduction (De Deckere et al., 1998). Pasture-finished beef is also leaner than grain-finished beef (Neel et al., 2007). An additional benefit of pasture finishing is an increase in the CLA content of beef (French et al., 2000; Steen and Porter, 2003; Realini et al., 2004). Conjugated linoleic acid is reported to have anticarcinogenic (Ip

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et al., 1999; Futakuchi et al., 2002; Yang et al., 2002a), cholesterol reducing, and antiatherosclerotic properties (Nicolosi et al., 1997; Kritchevsky et al., 2000). However, the time needed to finish cattle on pasture to optimize CLA and n-3 fatty acids is not clear.

We hypothesized that time on feed (pasture or feedlot) would affect the concentrations of CLA and n-3 fatty acids, as well as other fatty acids. Additionally, we hypothesized that ruminal fluid and serum may be useful tools to evaluate the fatty acid profiles of adipose tissue. The objectives of this research were to determine the differences in the fatty acid composition of adipose tissue from pasture-finished vs. feedlot-finished cattle and to determine the time required for changes in fatty acids to occur. The concentration of fatty acids, and changes in concentration over time, in cattle finished on pasture or on a feedlot diet were investigated. The relationship of pasture forages and feedlot diets to fatty acid concentration in ruminal fluid and serum, and the concentrations of fatty acids in adipose tissue, were also evaluated.

MATERIALS AND METHODS

All procedures were approved by the Virginia Tech Animal Care Committee.

Animals and Experimental Design

Forty-six Angus crossbred steers (296 ± 8.1 kg) were obtained from a stockering study conducted at Morgantown, WV, on April 21, 2003. The steers had been fed 3 diets formulated to attain 3 levels of ADG and were housed in confinement (Neel et al., 2007). The stockering diets were primarily composed of timothy hay, soybean hulls, and soybean meal. After the stockering phase, the steers were allotted at random within stockering treatment and pen to be finished in drylot on a corn silage-concentrate diet or on pasture, and then allotted at random within finishing treatment to 1 of 3 replications within each finishing treatment. A total of 24 steers (12/finishing treatment) were selected randomly for the present study. Feedlot pen replications 1, 2, and 3 housed 3, 6, and 3 steers that were used in the present study, whereas pasture replications 1, 2, and 3 housed 5, 3, and 4 steers, respectively.

Steers were shipped from Morgantown to the finishing sites and were fed timothy hay in drylot until the following day, when the study began. Steers finished in drylot (individually fed using Calan gates, American Calan, Northwood, NH) were kept at the Shenandoah Valley Research and Extension Center, Steeles Tavern, VA, and those finished on pasture were kept at the West Virginia University Demonstration Farm, Willow Bend, WV.

Treatments

Ingredient, chemical, and fatty acid composition of the diets are presented in Tables 1 and 2. The feedlot diet consisted of corn silage, cracked corn grain, soybean meal, limestone, and a vitamin and mineral supplement (vitamin A mixed with Champions Choice Trace mineral supplement at a rate to provide 20,000 IU/steer daily of vitamin A; Champions Choice Trace, Cargill Inc., Minneapolis, MN; 94% NaCl, 37% Na, 3,500 mg/kg of Zn, 2,000 mg/kg of Fe, 2,000 mg/kg of Mn, 300 mg/kg of Cu, 70 mg/kg of I, and 50 mg/kg of Co). No feed additives were included in the diet, and steers did not receive any implants throughout the study. Steers fed the feedlot diet were placed in 1 of the 3 feedlot pens on April 21, 2003, and remained in these pens until the end of the study on September 8, 2003. For the steers fed the feedlot diet, there was a transition period from hay to the corn silage-based diet over a 7-d period. After the steers received the corn silage-based diet for 16 d, corn grain was added to the diet. The amount of corn in the diet was increased gradually, and silage was decreased gradually until the diet consisted of 85% corn grain and 10% corn silage (DM basis; d 76 of the study). Refusals were removed, and new feed was fed once daily at approximately 0800 h. For each steer, the amount fed each day was based on the intake from the previous day. If a steer left no refusals for 2 consecutive days, then the amount fed daily was increased by approximately 2.3 kg (as fed).

The pasture-finished steers sequentially grazed pastures composed of 3 replicates of triticale (× *Triticosecale rimpaui*)/annual ryegrass (*Lolium multiflorum*), alfalfa (*Medicago sativa*)/orchardgrass (*Dactylis glomerata*), and a cool-season grass/legume mixture. The cool season grass/legume mixture consisted primarily of tall fescue (*Lolium arundinaceum*), orchardgrass, Kentucky bluegrass (*Poa pratensis*), and white clover (*Trifolium repens*). Each replication of the pasture-finishing treatment included 1 paddock of triticale/ryegrass, 2 paddocks of alfalfa/orchardgrass, and 5 paddocks of the cool season grass/legume mixture. Cattle grazed the cool-season grass/legume pastures from April 22, 2003 to July 2, 2003, and August 1, 2003 to August 26, 2003. The triticale/annual ryegrass pastures were grazed from July 3, 2003 to July 17, 2003. The alfalfa/orchardgrass mixture was grazed from July 18, 2003 to July 31, 2003, and August 28, 2003 to September 8, 2003. While on pasture, the steers had access to a mineral and vitamin supplement (Vigortone FC No. 35S, Vigortone Ag Products, Cedar Rapids, IA; 20% Ca, 3.5% P, 20.5% NaCl, 0.6% Mg, 0.4% K, 830 mg/kg of Cu, 26.4 mg/kg of Se, 2,000 mg/kg of Zn, 666,667 IU/kg of vitamin A, 66,667 IU/kg of vitamin D_3, and 222 IU/kg of vitamin E).

Sample Collection

Ruminal fluid, blood, and adipose tissue samples were obtained on d 0, 28, 84, and 140, beginning at approximately 0800 h at Steeles Tavern and 1300 h at Willow Bend. Samples were obtained before feeding at Steeles Tavern. Pasture forage samples were collected

Table 1. Ingredient and chemical composition of feedlot diets fed to steers at Steeles Tavern, VA, and of pasture forage samples at Willow Bend, WV

	Day of study		
Item	0 to 28	28 to 84	84 to 140
Ingredient composition of feedlot diets, % of DM			
Silage	88.8	37.5	17.5
Corn	1.8	55.6	76.6
Soybean meal	8.9	6.5	5.6
Limestone	0.2	0.2	0.1
Mineral and vitamin supplement	0.4	0.3	0.2
Chemical composition of feedlot diets, % of DM			
NDF	38.7	21.4	16.6
ADF	20.3	9.5	5.5
Cellulose	19.4	9.7	6.1
Lignin	2.5	1.5	1.3
CP	10.6	10.5	10.3
Chemical composition of pasture forages, % of DM			
NDF	56.4	61.7	62.0
ADF	27.6	34.0	33.1
Cellulose	26.4	30.4	28.3
Lignin	2.6	4.3	5.6
CP	20.4	12.7	16.0
Total nonstructural carbohydrates	10.1	12.4	6.5

at Willow Bend immediately after ruminal fluid and blood samples were obtained. Pasture forage samples were also obtained at 14-d intervals throughout the study, beginning at approximately 0800 h.

Approximately 200 mL of ruminal fluid were collected using a stomach tube with a strainer and a vacuum pump, and filtered through 4 layers of cheesecloth. A pH measurement of each sample was taken at that time using a portable pH meter (Acumet Mini pH Meter, model AP61, Fisher Scientific Co., Pittsburgh, PA). On d 0, it was possible to collect ruminal fluid only from 10 of the 12 steers allotted to the feedlot diet, possibly

Table 2. Fatty acid composition of feedlot diets fed to steers at Steeles Tavern, VA, and pasture forage samples at Willow Bend, WV

	Day of study		
Item	0 to 28	29 to 84	85 to 140
Total fatty acid[1] content of feedlot diets, mg/g of DM	47.8	34.7	34.8
Fatty acid, % of total fatty acids			
C14:0	0.1	0.1	—
C15:0	0.5	0.3	0.2
C16:0	15.8	13.4	11.9
C16:1 *cis*-9	0.1	0.1	0.1
C18:0	1.8	1.6	2.0
C18:1 *cis*-9	19.9	25.1	27.6
C18:2 n-6	58.4	57.1	56.7
C18:3 n-3	3.1	2.2	1.3
C20:2 n-6	0.3	0.2	0.1
Total fatty acid[1] content of pasture forages, mg/g of DM	54.3	27.8	23.8
Fatty acid, % of total fatty acids			
C14:0	0.1	0.2	0.2
C15:0	5.7	6.9	8.2
C16:0	9.5	11.9	12.7
C16:1 *cis*-9	0.6	0.5	0.6
C18:0	0.5	0.9	1.0
C18:1 *cis*-9	1.0	2.1	1.5
C18:2 n-6	6.9	9.4	10.1
C18:3 n-3	72.9	63.9	61.6
C20:2 n-6	0.5	0.9	0.9
C22:2 n-6	0.6	1.2	0.8
Unknown	1.6	2.0	2.4

[1]Includes the fatty acids quantified.

because of slight dehydration associated with shipping stress and perhaps having to adapt to new waterers (ball waterers vs. open troughs). Blood samples were obtained by jugular venipuncture, using two 15-mL Vacutainer (no additive) tubes (Becton Dickinson Corp., Franklin Lakes, NJ).

Biopsies of subcutaneous adipose tissue were obtained from the gluteal area on the left side immediately cranial to the tailhead. The biopsy site was clipped and surgically prepared with 3 alternate scrubs of 100% isopropyl alcohol and a 7.5% povidone-iodine solution (Betadine Surgical Scrub, The Purdue Frederick Co., Stamford, CT). Lidocaine (2% solution; total of 10 mL/animal; Vedco, St. Joseph, MO) was injected subcutaneously cranial to the site. A linear incision (approximately 5 cm) was made with a sterile scalpel through the skin. Approximately 1 g of adipose tissue was obtained. The incision was stapled closed. Procaine penicillin (300,000 units/mL; 20 mL/animal; Hanford Pharmaceuticals, Syracuse, NY) was administered subcutaneously in the neck to minimize infection.

The ruminal fluid and adipose tissue samples were placed immediately on dry ice. The blood samples were placed immediately on ice. Upon arrival at the laboratory (travel times varied depending on study location, traffic, and weather conditions), the blood was centrifuged at 816 × *g* for 15 min at room temperature (approximately 23°C), and serum was collected and stored at −20°C.

Random grab samples of the forage were collected from the paddocks the steers were grazing at the time of sampling. Also, samples from all paddocks that the steers had grazed since the previous forage sampling date were collected. Two diagonal strips (in a crisscrossed pattern) were sampled per paddock, by stopping at regular intervals (every 10 to 30 steps, depending on paddock size) and clipping a handful of forage at approximately 5-cm cutting height. A subsample (approximately 200 to 300 g, fresh weight) of each sample was obtained for subsequent macro DM and nutritive value determination. For subsequent fatty acid analysis, the remainder of each sample was placed in small cloth sample bags, immediately frozen in liquid N, and placed in a cooler with dry ice. Corn silage, cracked corn grain, soybean meal, and supplement samples were obtained daily, composited over 14-d periods, and subsampled.

Sample Storage and Preparation

Samples obtained for fatty acid analysis were stored in a freezer to prevent oxidation and structural changes in the fatty acids. Ruminal fluid, serum, and adipose tissue samples were stored at −65°C. Diet ingredient and forage samples were stored at −20°C. Ruminal fluid, adipose tissue, silage, and pasture forage samples for fatty acid analysis were freeze-dried (FreeZone 12L Freeze Dry System, Labconco Corp., Kansas City, MO). Dried ruminal fluid samples were ground immediately with a mortar and pestle. Freeze-dried silage and pasture forages were ground immediately to pass a 0.5-mm screen using a Wiley mill (Laboratory Mill Model 4, Thomas Scientific, Swedesboro, NJ). Ground forage samples were composited within replication for the 14-d periods. A subsample of cracked corn and soybean meal samples were ground with a Wiley Mill to pass through a 0.5-mm screen.

Pasture forage samples for nutritive value analysis were dried in a forced-air oven at 60°C for 48 h. The pasture forages and subsamples of corn, soybean meal, and freeze-dried silage were ground with a Wiley Mill through a 1-mm screen. Samples for nutritive value were stored at room temperature.

Chemical Analysis

Nutritive Value. Forage and feed samples were sequentially analyzed for NDF, ADF, cellulose, and lignin (Goering and Van Soest, 1970), as modified by using fiber bag technology (Ankom 200 and Daisy II Incubator, Ankom Technology Corp., Fairport, NY). Micro DM was determined (AOAC, 2000). The samples were analyzed for total N by the combustion method (AOAC, 2000) using a Perkin Elmer 2410 Nitrogen Analyzer (Perkin Elmer Inc., Norwalk, CT). Freeze-dried silage and pasture forage samples were utilized for N analysis, due to potential N volatilization as a result of oven drying. Total nonstructural carbohydrate analysis (Smith, 1981) was conducted on freeze-dried pasture forage samples.

Long Chain Fatty Acid Analysis. The fatty acid composition of forage, feed, ruminal fluid, serum, and adipose tissue was determined. Fatty acids were extracted and methylated by modification of the methods of Folch et al. (1957) and Park and Goins (1994), respectively. Briefly, 200 to 500 mg of diet or forage, 500 mg of ruminal fluid, 15 to 20 mg of adipose tissue, or 2 mL of serum were extracted. Ground or liquid samples were vortexed and adipose tissue was homogenized in 2:1 chloroform:methanol. After a 1-h extraction, samples were filtered (Whatman filter paper, 541), and 0.88% KCl was added to the sample. The sample was then shaken, centrifuged at 960 × *g* for 5 min at room temperature (approximately 23°C), and the aqueous layer discarded. The solvent was evaporated under N_2 using N-EVAP 112 Nitrogen Evaporation System (Organomation Associates Inc., Berlin, MA). For methylation, methylene chloride, hexane containing an internal standard, and 0.5 *M* NaOH were added to the samples. The samples were heated at 90 to 95°C for 10 min in a hot water bath. A 14% solution of BF_3 in methanol was added to each sample and heated at 90 to 95°C for 10 min. Deionized H_2O and hexane were added to each sample; the samples were then shaken and centrifuged at 960 × *g* for 5 min at room temperature (approximately 23°C). Anhydrous Na_2SO_4 was added to the samples and an aliquot of the top (hexane) layer was collected for fatty acid analysis.

Analysis of fatty acid methyl esters was performed on a HP 6890N gas chromatograph equipped with an autoinjector, autosampler, and flame ionization detector (Agilent Technologies Inc., Wilmington, DE). Separation of fatty acid methyl esters was performed using a 100 m × 0.25 mm internal diameter × 0.2 μm film thickness SP-2560 capillary column (Supelco, Bellefonte, PA). Ultra-pure H_2 was the carrier gas, and ultra-pure N_2 was the make-up gas.

Fatty acid identification and quantification were performed using ChemStation Software 10.01 (Agilent Technologies Inc.) by comparison with known standards (Matreya, LLC, Pleasant Gap, PA; Nu-Chek Prep Inc., Elysian, MN). Total fatty acids were calculated by summation of the fatty acids quantified (12:0, 14:0, 14:1, 15:0, 16:0, 16:1, 17:0, 17:1, 18:0, 18:1 *cis*-9, 18:1 *trans*-10, 18:1 *trans*-11, 18:2 *cis*-9, *trans*-11, 18:2 *trans*-10, *cis*-12, 18:2 *cis*-9, *cis*-11, 18:2 *trans*-9, *trans*-11, 18:2 n-6, 18:3 n-3, 20:2 n-6, 20:3 n-3, 20:4 n-6, 22:2 n-6, 22:3 n-3, 22:4 n-6, 22:5 n-3, and 22:6 n-3). Total SFA were calculated by summation of 12:0, 14:0, 15:0, 16:0, 17:0, and 18:0. Stearic acid consumption has not been associated with increased blood cholesterol (Tholstrup et al., 1994, 2003; Hunter et al., 2000); therefore, the total SFA excluding 18:0 were termed cholesterol raising SFA (**CR-SFA**). Total MUFA were calculated by summation of all fatty acids with 1 double bond, total PUFA were calculated by summation of all fatty acids with 2 or more double bonds. The ratio of n-6 to n-3 fatty acids were calculated by the sum of n-6 PUFA divided by the sum of n-3 PUFA.

Statistical Analyses

Data were analyzed using a repeated-measures ANOVA in the Mixed Procedure (SAS Inst. Inc., Cary, NC). The model included fixed effects of stockering treatment, finishing treatment, date of measurement, and finishing treatment × date of measurement interaction and a random effect of pen nested within finishing treatment. Random steer effects were included in the model as a repeated effect with an unstructured variance/covariance matrix across measurement dates. Effects of finishing treatment were tested with the pen within treatment mean square, and other fixed effects were tested with residual steer effects. Because the number of steers varied among pens, Satterthwaite's approximation was used to correct error df for tests of fixed effects and SEM varied among treatments (Satterthwaite, 1946). In addition, the pen within finishing treatment variance component frequency converged to zero, in which case all fixed effects in the model were tested against residual (steer) effects. Least squares means were compared using a Tukey test when the interaction effect was significant at $P < 0.05$. Specific preplanned comparisons were conducted (nonorthogonal contrasts), including testing for treatment effects within sampling date, and testing for time effects with treatment (comparison of values on d 0 vs. 28, 84, and 140; d 28 vs. 84; and d 84 vs. 140). Correlations were performed using the PROC CORR procedure of SAS to evaluate the relationship of ruminal fluid fatty acids to serum fatty acids. The relationships of ruminal fluid and serum to adipose tissue fatty acids were also evaluated by conducting correlations.

Because of little variation in some of the fatty acid isomers of the ruminal fluid data (due to data being zero or close to zero), the data did not fit normality assumptions and could not be analyzed using PROC MIXED. Therefore, a nonparametric Wilcoxon Rank Sum test (Ott and Longnecker, 2001) was used to make within date comparisons (to test treatment effects) of these specific fatty acid isomers (18:2 *trans*-10, *cis*-12; 18:2 *cis*-9, *cis*-11; and 18:2 *trans*-9, *trans*-11). Data are reported as raw means.

RESULTS AND DISCUSSION

Diets and Forages

The primary fatty acid observed in the pasture forages was linolenic acid, whereas the primary fatty acid observed in the feedlot diets was linoleic acid. Concentrations of linolenic acid in pasture forages decreased over time, whereas concentrations of pentadecylic acid, palmitic acid, and linoleic acid increased over time (Table 2). The changes observed in the fatty acid composition of the forages may be related to maturity, season, or weather. In the feedlot diet, concentrations of palmitic and linolenic acids decreased over time (Table 2). These changes in fatty acids over time may be due to changes in the ingredient composition of the diets during the study (Table 1). The ingredient composition was gradually changed (gradual increase in corn grain and decrease in corn silage) to prevent rumen upset because no ionophores were used in the current study. Ionophores are known to affect ruminal fatty acid biohydrogenation (Van Nevel and Demeyer, 1995; Fellner et al., 1997) and therefore could have confounded the results. Similarly, the use of implants was avoided because implants affect fat and lean deposition in cattle (Owens et al., 1995).

Ruminal Fluid

Overall, palmitic acid (ranging from 12.4 to 30.9% of total fatty acids) and stearic acid (ranging from 40.8 to 69.7% of total fatty acids) composed the greatest proportions of SFA in ruminal fluid (Table 3). Within date, there were differences ($P < 0.05$) in these 2 fatty acids due to dietary treatment, which may be attributed to differences in the fatty acid profiles of the diets or differences in production of these fatty acids by ruminal biohydrogenation. Concentrations of stearic and linoleic (18:2 n-6) acids were greater in the high-concentrate diet than pasture forages, which probably contributed to the greater amounts of stearic acid observed in the ruminal fluid from high-concentrate finished vs.

pasture-finished steers on d 28. Diet is known to influence ruminal production of SFA (Kucuk et al., 2001; Loor et al., 2003).

Concentrations of 18:1 *trans*-10 were greater ($P < 0.05$) in ruminal fluid obtained from steers in the feedlot finishing treatment than the pasture finishing treatment on d 84 and 140 (Table 4). Within the feedlot finishing treatment, ruminal 18:1 *trans*-10 concentrations were less ($P < 0.05$) on d 0 than all other sampling dates, less ($P < 0.05$) on d 28 than 84, and greater ($P < 0.05$) on d 84 than 140. Therefore, 18:1 *trans*-10 concentrations peaked on d 84 for the feedlot-fed cattle, which corresponded to the feeding period containing the greatest amount of grain. These fluctuations in 18:1 *trans*-10 may be attributed to shifts in ingredient composition of the diet because low-forage/high-concentrate diets may lead to 18:1 *trans*-10 production in the rumen and also may be an indicator of altered ruminal biohydrogenation (Loor et al., 2003, 2004).

Trans-vaccenic acid (18:1 *trans*-11) was greater ($P < 0.05$) in ruminal fluid obtained from pasture-finished steers than feedlot-finished steers on d 28, 84, and 140 (Table 4). Within the feedlot finishing treatment, *trans*-vaccenic acid concentrations were greater ($P < 0.05$) on d 0 than 140, indicating an overall decline. These differences in *trans*-vaccenic acid may be due to shifts in the ingredient composition of the diet, which may have altered ruminal biohydrogenation. The corn silage may have resulted in greater *trans*-vaccenic acid production as compared with the hay-based pretreatment stockering diet. However, with increasing grain in the diet, *trans*-vaccenic acid concentrations declined. Piperova et al. (2000) observed a 65% reduction in *trans*-vaccenic acid when cows were fed a high-concentrate (milk fat-depressing) diet, compared with a corn silage and alfalfa haylage-based control diet. Linoleic and linolenic acids are precursors of *trans*-vaccenic acid (Kellens et al., 1986). Linoleic acid was a primary fatty acid in the feedlot diet in the current study. However, biohydrogenation end products of linoleic and linolenic acids may be altered by dietary ingredients (amount of forage vs. concentrate), as seen with the *trans*-10 and *trans*-11 18:1 isomer concentrations in the current study. With increased amounts of grain in the diet, ruminal production of *trans*-10 18:1 increases, whereas *trans*-11 18:1 is subsequently decreased. Similar results were observed by Loor et al. (2003, 2004).

In the present study, within the pasture finishing treatment, *trans*-vaccenic acid concentrations were less ($P < 0.05$) on d 0 than all other sampling dates and were greater ($P < 0.05$) on d 28 than 84 (2.5, 13.6, 9.0, and 10.1% of total fatty acids on d 0, 28, 84, and 140, respectively). A precursor of *trans*-vaccenic acid is linolenic acid (Kellens et al., 1986). In the current study, the linolenic acid concentrations in the pasture forages declined after d 28 as compared with the first 28 d. This may explain the similar pattern observed in ruminal fluid *trans*-vaccenic acid content in the pasture-finished steers.

The *cis*-9, *trans*-11 CLA was the primary isomer of CLA found in the rumen of steers in both treatments (Table 4). Similar results were observed by Kucuk et al. (2001) and Loor et al. (2003, 2004). The concentrations of *cis*-9, *trans*-11 CLA were greater ($P < 0.05$) in ruminal fluid from the pasture-finished steers than the feedlot-finished steers on d 140. Ruminal concentrations of *cis*-9, *trans*-11 CLA were numerically less than *trans*-vaccenic acid in the current study, indicating the importance of endogenous synthesis in tissues. Concentrations of *cis*-9, *trans*-11 CLA in ruminal fluid ranged from 0.2 to 1.6% of total fatty acids, whereas the *trans*-vaccenic acid concentrations ranged from 0.8 to 13.6% of total fatty acids. Kucuk et al. (2001) observed *trans*-vaccenic acid and *cis*-9, *trans*-11 CLA duodenal flows of 7.5 and 0.2 g/d, respectively, in ewes fed a high forage diet (72.9% of DM). Loor et al. (2003) observed *trans*-vaccenic acid outflows from continuous culture fermenters ranging from 70.9 to 210.1 g/d, and *cis*-9, *trans*-11 CLA outflow ranging from 0.5 to 4.4 g/d. Their findings, and the results of the current study, are in agreement with the hypothesis that ruminal production of *cis*-9, *trans*-11 CLA is not the main pathway by which CLA concentrations increase in ruminant products. Endogenous (adipose/mammary tissue) synthesis is the primary mechanism by which *cis*-9, *trans*-11 CLA is produced. It is estimated that 64 to 91% of *cis*-9, *trans*-11 CLA in ruminant products is of endogenous origin (Griinari et al., 2000; Kay et al., 2004; Mosley et al., 2006).

The *trans*-10, *cis*-12 CLA was observed in small concentrations (0.08 and 0.04% of total fatty acids) only in ruminal fluid from feedlot-finished steers on d 84 and 140, respectively (Table 4). Kucuk et al. (2001) and Sackmann et al. (2003) observed increased duodenal flows of *trans*-10, *cis*-12 CLA with decreasing forage levels. Loor et al. (2003) observed increased *trans*-10, *cis*-12 CLA outflow from continuous culture fermenters fed orchardgrass or red clover with increased levels of corn supplementation.

Concentrations of linolenic acid (18:3 n-3) were less ($P < 0.05$) in the ruminal fluid from the feedlot-finished steers than the pasture finished steers on d 28, 84, and 140 (Table 5). These results were due to the increased linolenic acid content of the pasture as compared with the feedlot diet. Within the feedlot finishing treatment, concentration of linolenic acid decreased ($P < 0.05$) from d 0 to 28 and remained decreased throughout the remainder of the study. The low amount of linolenic acid observed in the ruminal fluid of feedlot-finished cattle was a result of the low amount of linolenic acid in the diet (maximum amount was 3.1% of total fatty acids). Additionally, the corn silage in the diet was decreased during the study, further reducing potential linolenic acid content the diet.

Concentrations of 20:2 n-6 and 22:2 n-6 were less ($P < 0.05$) in the ruminal fluid obtained from the feedlot-finished steers than pasture-finished steers on d 140 (Table 5). This treatment effect was also observed for

Table 3. The effect of feedlot or pasture finishing treatments on total, saturated, and monounsaturated fatty acid composition of ruminal fluid

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Item	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
n	3	3	3	3	3	3	3	3			
Total fatty acids,[1] mg/g of DM	12[bde]	65[a]	114[a]	129[a]	10	15	17	17	<0.001	<0.001	<0.001
	(1.2)	(7.0)	(18)	(17)	(1.1)	(7.0)	(18)	(17)			
Fatty acid, % of total											
C14:0	1.26[bd]	0.56	0.71	0.94[a]	1.50[bde]	0.52	0.66	0.58	0.45	<0.001	0.003
	(0.092)	(0.066)	(0.109)	(0.071)	(0.084)	(0.066)	(0.109)	(0.071)			
C14:1 *cis*-9	2.93	0.85	0.57	0.54	3.69	1.47	0.86	1.45	0.06	<0.001	0.10
	(0.29)	(0.19)	(0.20)	(0.17)	(0.28)	(0.19)	(0.19)	(0.17)			
C15:0	3.19	0.67	0.41	0.56	4.01	1.60	1.19	1.55	<0.001	<0.001	0.57
	(0.174)	(0.063)	(0.094)	(0.070)	(0.161)	(0.063)	(0.094)	(0.070)			
C16:0	30.1[bde]	15.1	12.4[a]	12.7[a]	30.9[bde]	15.8	17.8	18.8	<0.001	<0.001	0.004
	(1.49)	(0.64)	(1.08)	(0.64)	(1.38)	(0.64)	(1.08)	(0.64)			
C16:1 *cis*-9	2.05[bde]	0.42	0.25	0.22[a]	1.89[bde]	0.46	0.70	0.49	0.08	<0.001	0.01
	(0.165)	(0.047)	(0.117)	(0.036)	(0.151)	(0.047)	(0.117)	(0.036)			
C17:0	1.726[bde]	0.440[a]	0.529	0.405[a]	1.911[bde]	0.762	0.635	0.734	<0.001	<0.001	0.04
	(0.061)	(0.030)	(0.059)	(0.025)	(0.057)	(0.030)	(0.059)	(0.025)			
C17:1 *cis*-9	0.381[e]	0.285	0.202	0.156	0.239	0.156	0.134[d]	0.199	0.06	0.01	0.001
	(0.068)	(0.030)	(0.026)	(0.020)	(0.063)	(0.029)	(0.025)	(0.019)			
C18:0	41.5[be]	69.7[ac]	52.1	68.6	40.8[be]	58.2	49.0	56.5	0.005	<0.001	0.005
	(1.5)	(1.3)	(4.7)	(3.7)	(1.4)	(1.3)	(4.7)	(3.7)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]Includes the fatty acids quantified; data are reported as least squares means (±SEM).

Table 4. The effect of feedlot or pasture finishing treatments on C18:1 and C18:2 fatty acid isomers in ruminal fluid

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
18:1 *cis*-9	4.5	3.2	8.3	5.3	3.5	1.9	9.0	2.8	0.34	0.001	0.88
	(0.30)	(0.39)	(2.44)	(1.52)	(0.28)	(0.39)	(2.44)	(1.52)			
C18:1 *trans*-10	0.19[bef]	1.10[c]	13.55[ad]	3.17[a]	0.05	0.41	0.25	0.35	<0.001	<0.001	<0.001
	(0.03)	(0.16)	(2.80)	(0.44)	(0.03)	(0.16)	(2.80)	(0.44)			
C18:1 *trans*-11	2.72[f]	4.52[a]	2.05[a]	0.84[a]	2.46[bef]	13.55[c]	8.95	10.05	<0.001	<0.001	<0.001
	(0.15)	(0.62)	(0.97)	(0.40)	(0.15)	(0.62)	(0.97)	(0.40)			
cis-9, *trans*-11 CLA	1.57[bef]	0.79[c]	0.22	0.25[a]	1.09	0.41	0.80	1.06	0.23	<0.001	<0.001
	(0.20)	(0.10)	(0.14)	(0.11)	(0.18)	(0.10)	(0.14)	(0.11)			
trans-10, *cis*-12 CLA	—	—	0.082[g]	0.044[g]	—	—	—	—	<0.05	<0.05	<0.05
	—	—	(0.084)	(0.057)	—	—	—	—			
cis-9, *cis*-11 CLA	—	—	—	—	—	0.32	0.32	0.28	<0.05	<0.05	<0.05
	—	—	—	—	—	(0.21)	(0.27)	(0.24)			
trans-9, *trans*-11 CLA	—	—	0.03	0.01[g]	—	—	0.08	—	<0.05	<0.05	<0.05
	—	—	(0.079)	(0.018)	—	—	(0.103)	—			
C18:2 n-6	2.61	1.71	7.65	5.43	2.13	0.95	5.74	2.34	0.11	<0.001	0.50
	(0.26)	(0.18)	(1.87)	(1.72)	(0.25)	(0.17)	(1.87)	(1.72)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[g]Wilcoxon analysis performed on raw means: within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).

22:2 n-6 on d 28 and 84. Within both treatments, ruminal fluid concentrations of 20:2 n-6 were greater ($P < 0.05$) on d 0 than all other sampling dates. Concentrations of 22:2 n-6 were also greater ($P < 0.05$) on d 0. Dietary content of 20:2 n-6 and 22:2 n-6 may have contributed to these results.

Concentrations of docosapentaenoic (**DPA**; 22:5 n-3) were greater ($P < 0.05$) in ruminal fluid from the pasture-finished steers than feedlot-finished steers on d 28 (Table 5). Within both treatments, DPA was greater ($P < 0.05$) on d 0 than all other sampling dates. The greater amounts of DPA in the ruminal fluid from pasture-finished steers may have been due to microbial elongation of linolenic acid from pasture forages.

Serum

Serum total fatty acids, SFA, and MUFA are reported in Table 6. Similar to ruminal fluid, palmitic acid and stearic acid composed the greatest proportion of SFA observed in serum. Myristoleic (14:1) and pentadecylic (15:0) acids were less ($P < 0.05$) in serum obtained from feedlot-finished steers than pasture-finished steers on d 28, 84, and 140. Myristic (14:0) and 17:1 *cis*-9 in serum were less ($P < 0.05$) in the feedlot-finished steers than pasture-finished steers on d 84 and 140. The same effect was seen for oleic acid (18:1 *cis*-9; Table 7). The effect of sampling date on serum fatty acids was not consistent because, within the feedlot finishing treatment, myristic, myristoleic, and pentadecylic acids generally declined ($P < 0.05$) after d 0, whereas the opposite effect was seen in the pasture-finishing treatment. Palmitic acid concentrations were greater ($P < 0.05$) on d 0 than 84 and 140 in the feedlot-fed cattle. These inconsistencies may be a result of differences in the fatty acid content or biohydrogenation of the diets. Additionally, lipid metabolism by various tissues within the steers may have influenced the results. For instance, the enzyme Δ9 desaturase has the ability to add a double bond to SFA, and liver, mammary, and adipose tissues are known to have this enzyme (Wahle, 1974; Pollard et al., 1980; Adlof et al., 2000; Santora et al., 2000). The decreased concentrations of MUFA in serum may possibly be an indicator of less Δ9 desaturase activity in the feedlot-finished steers compared with pasture-finished steers. Yang et al. (1999) observed less desaturase activity in adipose tissue from grain-finished as compared with pasture-finished cattle. Additionally, Loor and Herbein (1998) and Chouinard et al. (1999a,b) observed increased ratios of SFA to MUFA in milk obtained from cows fed high-grain diets with depressed milk fat as compared with control cows with normal milk fat production.

We are not aware of any studies that have directly compared the blood fatty acid profiles of ruminants consuming forage vs. high-concentrate diets. Although not entirely analogous, researchers have evaluated the effects of oil supplements on plasma fatty acid profiles

Table 5. The effect of feedlot or pasture finishing treatments on long chain n-3 and n-6 PUFA in ruminal fluid

	Day of study								Effect		
	Feedlot finishing treatment				Pasture finishing treatment						
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
C18:3 n-3	1.29[bef] (0.17)	0.13[a] (0.06)	0.41[a] (0.13)	0.33[a] (0.14)	1.26 (0.16)	1.21 (0.06)	1.59 (0.13)	1.30 (0.14)	<0.001	<0.001	0.007
C20:2 n-6	0.85[bef] (0.116)	0.32 (0.038)	0.27 (0.095)	0.20[a] (0.039)	1.09[bf] (0.108)	0.43 (0.038)	0.71 (0.095)	0.49 (0.039)	0.003	<0.001	<0.001
C22:2 n-6	0.175 (0.059)	0.001[a] (0.016)	0.002[a] (0.022)	—[a] (0.007)	0.162 (0.055)	0.310[c] (0.016)	0.207 (0.022)	0.185 (0.007)	<0.001	<0.001	<0.001
C22:5 n-3 (DPA)	2.13[bef] (0.273)	0.16[a] (0.109)	0.20 (0.208)	0.19 (0.112)	2.43[bef] (0.256)	1.13 (0.108)	1.18[d] (0.208)	0.50 (0.112)	0.008	<0.001	<0.001
C22:6 n-3 (DHA)	0.539 (0.096)	0.114 (0.042)	0.123 (0.049)	0.122 (0.044)	0.822 (0.089)	0.340 (0.042)	0.230 (0.049)	0.265 (0.044)	0.02	<0.001	0.12

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).

Table 6. The effect of feedlot or pasture finishing treatments on total, saturated, and monounsaturated fatty acid composition of serum

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Item	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
n	3	3	3	3	3	3	3	3			
Total fatty acids,[1] μg/mL	1,034[b] (183)	578[c] (179)	936 (178)	1,085 (192)	1,045 (183)	1,092 (179)	936 (178)	1,093 (192)	0.54	<0.001	<0.001
Fatty acid, % of total											
C14:0	1.060[ef] (0.046)	0.960[c] (0.079)	0.550[a] (0.077)	0.733[a] (0.042)	1.057[ef] (0.045)	1.266 (0.079)	1.547 (0.077)	1.342 (0.042)	<0.001	0.31	<0.001
C14:1 *cis*-9	1.143[bef] (0.054)	0.784[ac] (0.056)	0.439[a] (0.103)	0.411[a] (0.037)	1.083[bef] (0.054)	1.589 (0.056)	1.855[d] (0.103)	1.501 (0.037)	<0.001	<0.001	<0.001
C15:0	1.192[bef] (0.059)	0.724[a] (0.053)	0.637[a] (0.058)	0.664[a] (0.053)	1.103 (0.058)	1.169 (0.052)	1.213 (0.058)	1.238 (0.053)	0.005	<0.001	<0.001
C16:0	14.22[ef] (0.49)	14.16[c] (0.85)	10.57 (0.60)	11.48 (0.52)	13.86[e] (0.48)	12.86 (0.85)	12.27 (0.60)	12.15 (0.52)	0.81	<0.001	0.005
C16:1 *cis*-9	1.84[ef] (0.17)	1.98[c] (0.20)	1.12[a] (0.17)	1.20 (0.13)	1.99 (0.17)	1.87 (0.20)	2.24[d] (0.17)	1.80 (0.13)	0.09	0.001	<0.001
C17:0	1.23 (0.055)	1.11 (0.077)	1.17 (0.063)	1.05 (0.050)	1.16 (0.055)	0.95 (0.077)	1.00 (0.062)	1.00 (0.050)	0.18	<0.001	0.12
C17:1 *cis*-9	0.685[ef] (0.057)	0.713[c] (0.048)	0.328[a] (0.040)	0.406[a] (0.297)	0.777 (0.057)	0.741 (0.048)	0.931[d] (0.040)	0.699 (0.030)	<0.001	<0.001	<0.001
C18:0	16.8 (0.52)	18.5 (1.03)	15.2 (0.78)	17.3 (0.52)	16.2 (0.52)	19.0 (1.03)	16.3 (0.78)	18.0 (0.52)	0.61	<0.001	0.05

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]Includes the fatty acids quantified; data are reported as least squares means (±SEM).

Table 7. The effect of feedlot or pasture finishing treatments on C18:1 and C18:2 fatty acid isomers in serum

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
C18:1 *cis*-9	15.8[ef]	17.7[c]	8.3[a]	9.8[a]	17.3	17.9	19.5[d]	15.8	<0.001	<0.001	<0.001
	(0.82)	(1.13)	(0.83)	(0.59)	(0.82)	(1.13)	(0.83)	(0.59)			
C18:1 *trans*-10	0.75[ef]	0.74[ac]	1.60[ad]	1.06[a]	0.76[bef]	0.01	0.01	0.01	<0.001	<0.001	<0.001
	(0.079)	(0.079)	(0.122)	(0.067)	(0.079)	(0.078)	(0.122)	(0.067)			
C18:1 *trans*-11	0.81	1.03[ac]	0.54[a]	0.45[a]	0.78[bef]	3.60[c]	2.72	2.86	<0.001	<0.001	<0.001
	(0.05)	(0.12)	(0.14)	(0.12)	(0.05)	(0.12)	(0.14)	(0.12)			
cis-9, *trans*-11 CLA	0.797[ef]	0.673[c]	0.207[a]	0.212[a]	0.890	0.946	1.045[d]	0.786	0.005	<0.001	<0.001
	(0.075)	(0.083)	(0.085)	(0.060)	(0.075)	(0.082)	(0.085)	(0.060)			
trans-10, *cis*-12 CLA	0.047[ef]	0.077[a]	0.106[a]	0.097[a]	0.053[bef]	0.018	0.015	0.014	<0.001	0.26	<0.001
	(0.008)	(0.012)	(0.006)	(0.005)	(0.008)	(0.012)	(0.006)	(0.005)			
cis-9, *cis*-11 CLA	2.0	2.0	2.8	0.1[a]	0.1[b]	0.2	0.2	0.2	0.35	0.003	<0.001
	(1.3)	(1.3)	(1.9)	(0.02)	(1.3)	(1.3)	(1.9)	(0.02)			
trans-9, *trans*-11 CLA	0.545[bef]	0.300[a]	0.140[a]	0.146[a]	0.508[bef]	1.463	1.283	1.300	<0.001	<0.001	<0.001
	(0.044)	(0.056)	(0.078)	(0.051)	(0.043)	(0.055)	(0.078)	(0.051)			
C18:2 n-6	23.3[ef]	22.8[c]	46.7[a]	44.6[a]	23.1[be]	14.6	12.3[d]	19.3	0.001	<0.001	<0.001
	(1.8)	(2.2)	(2.6)	(2.3)	(1.8)	(2.1)	(2.6)	(2.3)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).

and observed similar results (Gaynor et al., 1994; Loor and Herbein, 2003).

The 18:1 *trans*-10 was greater ($P < 0.05$) in the serum from feedlot-finished steers than pasture-finished steers on d 28, 84, and 140 (Table 7). Within the feedlot finishing treatment, 18:1 *trans*-10 was greater ($P < 0.05$) on d 84 than all other sampling dates and less ($P < 0.05$) on d 0 than 140. Within the pasture-finishing treatment, the value on d 0 was greater ($P < 0.05$) than all other sampling dates. These results are similar to those observed for ruminal fluid. These fluctuations in 18:1 *trans*-10 may be attributed to shifts in ingredient composition of the diet, as low-forage/high-concentrate diets may lead to 18:1 *trans*-10 production in the rumen and also may be an indicator of altered ruminal biohydrogenation. On d 84, the greatest level of 18:1 *trans*-10 in the feedlot-finished steers was observed in ruminal fluid and serum. This sampling date corresponded with the period containing the greatest amount of grain inclusion in the feedlot diet.

Trans-vaccenic acid (18:1 *trans*-11) concentrations in serum from the feedlot-finished steers were less ($P < 0.05$) than the pasture-finished steers on d 28, 84, and 140. Within the feedlot finishing treatment, *trans*-vaccenic acid decreased ($P < 0.05$) from d 28 to 84. In the pasture finishing treatment, the amount of *trans*-vaccenic acid on d 0 was less ($P < 0.05$) than on all other sampling dates and was greater ($P < 0.05$) on d 28 than on d 84. These changes in *trans*-vaccenic acid in serum reflected the *trans*-vaccenic acid content of the ruminal fluid ($r = 0.91$; $P < 0.0001$). Pasture-finished steers contained greater *trans*-vaccenic acid in ruminal fluid and serum, compared with feedlot-finished steers, which peaked on d 28. The greater concentrations of *trans*-vaccenic acid in ruminal fluid and serum from pasture-finished steers could be attributed to the biohydrogenation of the fatty acids in the pasture forages. A precursor of *trans*-vaccenic acid is linolenic acid (Kellens et al., 1986). In the current study, the linolenic acid concentrations in the pasture forages that the steers grazed declined after d 28 and remained decreased, as compared with the first 28 d.

Serum concentrations of *cis*-9, *trans*-11 CLA were greater ($P < 0.05$) in the pasture-finished steers than the feedlot-finished steers on d 84 and 140 (Table 7). Within the feedlot finishing treatment, *cis*-9, *trans*-11 CLA decreased ($P < 0.05$) from d 28 to 84, and values on d 0 were greater ($P < 0.05$) than on d 84 and 140. Within the pasture-finishing treatment, *cis*-9, *trans*-11 CLA concentrations were greater ($P < 0.05$) on d 84 than 140. Ruminal fluid and serum *cis*-9, *trans*-11 CLA were correlated ($r = 0.42$; $P < 0.0001$).

The concentrations of *trans*-10, *cis*-12 CLA were greater ($P < 0.05$) in serum from feedlot-finished steers than pasture-finished steers on d 28, 84, and 140 (Table 7), but all values were reduced. Within the feedlot finishing treatment, *trans*-10, *cis*-12 CLA was less ($P < 0.05$) on d 0 than d 84 and 140, presumably as a result of the decline in the corn silage content of the feedlot diets. Decreasing forage content of diets results in increased ruminal production of *trans*-10, *cis*-12 CLA (Kucuk et al., 2001; Sackmann et al., 2003). Within the pasture finishing treatment, *trans*-10, *cis*-12 CLA was greater ($P < 0.05$) on d 0 than all other sampling dates, which may have been a result of the pretreatment stockering diet (hay based with concentrate supplements). The greater concentrations of *trans*-10, *cis*-12 CLA in serum from steers in the feedlot finishing treatment, compared with pasture finishing treatment, may be an indicator of altered ruminal biohydrogenation. Ruminal fluid and serum *trans*-10, *cis*-12 CLA were correlated ($r = 0.36$; $P < 0.0004$); therefore, serum may be a useful indicator of ruminal biohydrogenation because fatty acids absorbed from the digestive tract are transported in the blood.

Linoleic acid was greater ($P < 0.05$) in the serum obtained from the feedlot-finished steers than pasture-finished steers on d 84 and 140 (Table 7). Within the pasture finishing treatment, serum concentrations of linoleic acid were greater ($P < 0.05$) on d 0 than d 28 and 84, and increased ($P < 0.05$) from d 84 to 140. These differences may be attributed to the greater content of this fatty acid in the feedlot diets compared with the pasture forages. Fluctuations within treatment generally reflect the content of linolenic acid within the diets as affected by sampling date and diet ingredient composition.

Linolenic acid and 22:3 n-3 concentrations were greater ($P < 0.05$) in the serum of pasture-finished steers than high concentrate finished steers on d 28, 84, and 140 (Table 8). Concentrations of 20:3 n-3 and DPA were greater ($P < 0.05$) in the serum of pasture-finished steers than high concentrate finished steers on d 84. Serum docosahexaenoic acid (C22:6 n-3) concentrations were less ($P < 0.05$) in the feedlot-finished steers on d 84 and 140.

Overall, concentrations of n-3 fatty acids were greater in the ruminal fluid and serum from the pasture-finished steers, compared with the feedlot-finished steers. Ruminal fluid and serum linoleic and linolenic acids were correlated ($r = 0.31$; $P = 0.002$, and $r = 0.70$; $P < 0.0001$, respectively). Ruminal fluid and serum DPA and C22:6 n-3 were correlated ($r = 0.40$; $P < 0.0001$). The greater n-3 content of ruminal fluid and serum in pasture-finished steers may be attributed to the greater linolenic acid content of the pasture forages, as compared with feedlot diets. Forage linolenic acid represented a large pool of n-3 fatty acid, which was potentially elongated into longer n-3 fatty acids within the animals. Tissue elongation of linolenic acid could have contributed to the serum pool of n-3 fatty acids.

Adipose Tissue

The total fatty acid content (mg/g) of subcutaneous adipose tissue did not differ between treatments or sampling date (Table 9). In regards to SFA, the proportion of palmitic acid was greater ($P < 0.05$) in the adipose

Table 8. The effect of feedlot or pasture finishing treatments on long chain n-3 and n-6 PUFA in serum

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
C18:3 n-3	6.79[bef]	1.47[a]	0.79[a]	0.90[a]	7.11[bef]	12.93	12.42	13.17	<0.001	0.49	<0.001
	(0.37)	(0.45)	(0.63)	(0.42)	(0.36)	(0.44)	(0.63)	(0.42)			
C20:2 n-6	0.148[ef]	0.153[c]	0.086	0.078	0.127	0.126	0.119	0.119	0.66	<0.001	<0.001
	(0.012)	(0.016)	(0.011)	(0.010)	(0.012)	(0.016)	(0.011)	(0.010)			
C20:3 n-3	0.0392[f]	0.0417	0.0233[a]	0.0233	0.0442	0.0525	0.0575	0.0400	0.01	0.001	0.007
	(0.0054)	(0.0054)	(0.0055)	(0.0047)	(0.0054)	(0.0054)	(0.0055)	(0.0047)			
C20:3 n-6	2.06	1.90	2.23[a]	2.49[a]	2.17[be]	1.47	1.26[d]	1.78	0.07	<0.001	<0.001
	(0.15)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)	(0.14)	(0.15)			
C20:4 n-6	2.83[e]	2.61	2.07	2.44[a]	2.67[bef]	1.87	1.77	1.69	0.005	<0.001	0.03
	(0.18)	(0.16)	(0.14)	(0.13)	(0.18)	(0.16)	(0.14)	(0.13)			
C22:2 n-6	0.057[ef]	0.059	0.024	0.028	0.037	0.057	0.054	0.036	0.76	0.005	0.004
	(0.009)	(0.015)	(0.008)	(0.007)	(0.009)	(0.015)	(0.008)	(0.007)			
C22:3 n-3	2.09[bef]	0.78[ac]	0.20[a]	0.19[a]	2.01[b]	2.65	2.50	2.16	<0.001	<0.001	<0.001
	(0.100)	(0.087)	(0.125)	(0.063)	(0.100)	(0.087)	(0.125)	(0.063)			
C22:4 n-6	0.274[bef]	0.454[ac]	0.696[a]	0.708[a]	0.263	0.197	0.207	0.243	<0.001	<0.001	<0.001
	(0.019)	(0.021)	(0.031)	(0.028)	(0.019)	(0.021)	(0.031)	(0.028)			
C22:5 n-3 (DPA)	2.04[ef]	1.98[c]	0.81[a]	0.62[a]	2.05	1.84	2.07	2.01	<0.001	<0.001	<0.001
	(0.078)	(0.131)	(0.094)	(0.045)	(0.08)	(0.132)	(0.094)	(0.045)			
C22:6 n-3 (DHA)	0.82[ef]	0.98[c]	0.33[a]	0.25[a]	0.84[bef]	0.55	0.60[d]	0.44	0.82	<0.001	<0.001
	(0.045)	(0.071)	(0.039)	(0.033)	(0.045)	(0.071)	(0.039)	(0.033)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).

tissue of feedlot-finished steers than pasture-finished steers on d 28 (Table 9). French et al. (2000), Yang et al. (2002b), and Realini et al. (2004) observed greater palmitic acid concentrations in grain-fed, as compared with pasture-fed beef. Within the pasture-finishing treatment, palmitic acid was greater ($P < 0.05$) on d 0 than on d 28 and 84, which may have been an artifact of the pretreatment stockering diet. Overall, the results observed for adipose tissue palmitic acid may be attributed to the palmitic acid content of the diets, possible microbial conversion of other dietary fatty acids into palmitic acid within the rumen environment, as well as by de novo synthesis within the adipose tissue. Except for during the last period, the feedlot diet had greater palmitic and total fatty acid content than the pasture forages. Ruminal fluid and serum palmitic acid did not correlate with adipose tissue palmitic acid (r = 0.19 and 0.09, respectively; $P > 0.05$).

The feedlot-finished steers had less ($P < 0.05$) stearic acid in adipose tissue on d 84 and 140 than pasture-finished steers (Table 9). Within the feedlot finishing treatment, the proportion of stearic acid decreased ($P < 0.05$) throughout the study. In the pasture finishing treatment, stearic acid decreased ($P < 0.05$) in adipose tissue from d 84 to 140. Ruminal fluid and serum stearic acid concentrations did not correspond to adipose tissue. Ruminal fluid and adipose tissue stearic acid were negatively correlated (r = −0.28; $P = 0.006$). Serum and adipose tissue stearic acid were not correlated ($P > 0.05$). The implications of these results are unclear and may have been affected by de novo synthesis within adipose tissue. Results of previous research are inconsistent when evaluating the effects of forage- vs. grain-based diets or time on feed on these SFA (French et al., 2000; Yang et al., 2002b; Realini et al., 2004). The varied results may have been due to differences in diet composition, time on feed, type of tissue sample analyzed, or genetics.

Trans-vaccenic acid (18:1 *trans*-11) proportion was greater ($P < 0.05$) in the adipose tissue obtained from pasture-finished steers than feedlot-finished steers on d 28, 84, and 140 (Table 10). For this fatty acid, ruminal fluid and serum concentrations were consistent with the differences observed in adipose tissue due to treatment, as the concentrations of *trans*-vaccenic acid were considerably greater (by as much as 91%; $P < 0.05$) in the pasture-finished steers on d 28, 84, and 140, compared with the feedlot-finished steers. Ruminal fluid and serum *trans*-vaccenic acid were correlated with adipose tissue *trans*-vaccenic acid (r = 0.71 and 0.79; $P < 0.0001$, respectively). Yang et al. (2002b) observed no difference in total lipid proportions of *trans*-vaccenic acid in beef from pasture- and grain-finished cattle.

No differences due to sampling date were observed for *trans*-vaccenic acid within the feedlot finishing treatment (Table 10). Within the pasture finishing treatment, *trans*-vaccenic acid was less ($P < 0.05$) in adipose tissue samples on d 0 than on all other sampling dates. Similar observations were made for *trans*-vaccenic acid concentration of ruminal fluid and serum, which was less ($P < 0.05$) on d 0 than the remainder of the sampling dates within the pasture finishing treatment. Yang et al. (1999) observed no effects of time on a high-grain diet on the *trans*-vaccenic acid content of beef.

Concentrations of *cis*-9, *trans*-11 CLA were greater ($P < 0.05$) in adipose tissue obtained from pasture-finished steers than feedlot-finished steers on d 28, 84, and 140 due to the greater amounts of forage intake (Table 10). French et al. (2000) observed that with increasing amounts of pasture intake, the amount of CLA in beef increased. Ruminal fluid and serum content of *cis*-9, *trans*-11 CLA was greater ($P < 0.05$) in the pasture-finished steers, compared with feedlot-finished steers on d 140. Ruminal fluid and adipose tissue *cis*-9, *trans*-11 CLA were correlated (r = 0.40; $P < 0.0001$). However, serum *cis*-9, *trans*-11 CLA appeared to be a better indicator of adipose tissue concentrations of this fatty acid because serum and adipose tissue *cis*-9, *trans*-11 CLA were more strongly correlated (r = 0.72; $P < 0.0001$).

Within the feedlot finishing treatment, there was an overall decline in *cis*-9, *trans*-11 CLA adipose tissue concentrations because values on d 0 were greater ($P < 0.05$) than on all other sampling dates. Within the pasture finishing treatment, there were no differences due to sampling date. Noci et al. (2005) investigated the effect of duration of grazing on fatty acids, including *cis*-9, *trans*-11 CLA, in adipose tissue. They observed a linear increase in *cis*-9, *trans*-11 CLA in subcutaneous adipose tissue from heifers that grazed up to 158 d on pasture, compared with the feedlot-fed control slaughtered at d 0. The contrasting results observed between their study and those observed in the current study may have been due to differences in the feeding regime, diet composition, and sampling protocols. In the study conducted by Noci et al. (2005), the authors fed grass silage and a concentrate supplement to the cattle, which may have contributed to relatively low concentrations of *cis*-9, *trans*-11 CLA in adipose tissue when the animals were introduced to a perennial ryegrass (*Lolium perenne*) pasture. The authors did not report changes in diet fatty acid composition over time. In contrast, in the current study the cattle were fed a high fiber (timothy hay and soybean hull-based) diet before the initiation of the study and had relatively greater content of *cis*-9, *trans*-11 CLA in adipose tissue when sampled on d 0. Additionally, in the study conducted by Noci et al. (2005) the cattle were serially slaughtered over the study after being allowed to graze for 0, 44, 90, or 158 d. The authors analyzed samples obtained from LM. However, in the current study subcutaneous adipose tissue biopsies were obtained from the same animals at set intervals (d 0, 28, 84, and 140) throughout the study. All animals were kept on the treatment diets for the entire duration of the study until slaughtered.

Endogenous synthesis of *cis*-9, *trans*-11 CLA appears to be the primary mechanism of CLA production in ruminant products (Griinari et al., 2000; Corl et al., 2001; Kay et al., 2004). Therefore, maintaining increased con-

Table 9. The effect of feedlot or pasture finishing treatments on total, saturated, and monounsaturated fatty acid composition of subcutaneous adipose tissue

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Item	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
n	3	3	3	3	3	3	3	3			
Total fatty acids,[1] mg/g of tissue	693	746	898	984	838	845	840	840	0.69	0.44	0.046
	(94)	(85)	(96)	(83)	(94)	(84)	(96)	(82)			
Fatty acid, % of total											
C12:0	0.274	0.186	0.134	0.138	0.344	0.149	0.167	0.163	0.68	0.37	0.08
	(0.128)	(0.026)	(0.026)	(0.024)	(0.128)	(0.026)	(0.025)	(0.024)			
C14:0	2.54	1.68	1.23	1.35	2.80	2.12	1.65	1.69	0.30	<0.001	0.85
	(0.27)	(0.25)	(0.21)	(0.20)	(0.27)	(0.25)	(0.21)	(0.19)			
C14:1 *cis*-9	0.59	0.67	0.43	0.56	0.62	0.56	0.48	0.58	0.99	0.001	0.20
	(0.098)	(0.099)	(0.077)	(0.079)	(0.098)	(0.099)	(0.077)	(0.078)			
C15:0	0.68[bde]	0.41	0.37	0.37	0.59	0.60	0.61	0.55	0.31	0.007	0.02
	(0.09)	(0.07)	(0.08)	(0.08)	(0.09)	(0.07)	(0.08)	(0.08)			
C16:0	32.6	34.7[a]	31.5	31.7	33.9[bd]	29.1	29.4	30.3	0.04	0.08	0.003
	(0.85)	(1.12)	(1.01)	(0.89)	(0.85)	(1.12)	(1.01)	(0.89)			
C16:1 *cis*-9	2.89[be]	5.52[ac]	4.02	4.21	3.26	3.73	3.75	4.20	0.11	<0.001	0.004
	(0.30)	(0.33)	(0.25)	(0.21)	(0.30)	(0.33)	(0.25)	(0.21)			
C17:0	1.01[d]	0.84[c]	1.42	1.37	0.86	1.00	0.96	1.00	0.13	0.01	0.004
	(0.09)	(0.08)	(0.12)	(0.14)	(0.09)	(0.08)	(0.12)	(0.14)			
C17:1 *cis*-9	0.54[de]	0.67[c]	1.17[a]	1.29[a]	0.45	0.49	0.57	0.61	<0.001	<0.001	<0.001
	(0.06)	(0.06)	(0.10)	(0.08)	(0.06)	(0.06)	(0.10)	(0.08)			
C18:0	19.3[bde]	14.0	11.9[a]	9.9[a]	17.8	19.1	18.9[d]	17.0	0.002	<0.001	<0.001
	(1.19)	(1.39)	(0.78)	(0.76)	(1.19)	(1.39)	(0.78)	(0.76)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]Includes the fatty acids quantified; data are reported as least squares means (±SEM).

Table 10. The effect of feedlot or pasture finishing treatments on C18 fatty acid isomers in subcutaneous adipose tissue

	Day of study									
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
C18:1 *cis*-9	33.9[de] (1.5)	37.5[c] (1.2)	43.1[a] (1.7)	44.3[a] (1.5)	33.6 (1.5)	33.2 (1.2)	32.9 (1.7)	34.1 (1.5)	0.002	<0.001	0.003
C18:1 *trans*-11	3.14 (0.37)	1.73[a] (0.53)	2.72[a] (0.50)	2.75[a] (0.44)	3.20[bde] (0.37)	7.03 (0.53)	7.91 (0.50)	7.22 (0.44)	<0.001	<0.001	<0.001
C18:2 n-6	0.85[de] (0.11)	0.93 (0.11)	1.40[a] (0.12)	1.50[a] (0.11)	0.74 (0.11)	0.72 (0.11)	0.67 (0.12)	0.63 (0.11)	0.03	<0.001	<0.001
cis-9, *trans*-11 CLA	1.17[bde] (0.18)	0.72[ac] (0.11)	0.26[a] (0.08)	0.21[a] (0.11)	1.25 (0.18)	1.41 (0.11)	1.32 (0.08)	1.23 (0.11)	<0.001	<0.001	0.002
C18:3 n-3	0.50 (0.10)	0.35 (0.10)	0.30[a] (0.08)	0.24[a] (0.08)	0.64 (0.10)	0.80 (0.10)	0.71 (0.08)	0.78 (0.08)	0.002	0.45	0.05

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).

centrations of *trans*-vaccenic acid in ruminal fluid, by pasture finishing cattle, is critical in optimizing CLA content in ruminant products. Ruminal production of *trans*-vaccenic acid is reduced, and the production of an alternate isomer (18:1 *trans*-10) is greatly increased with feeding high-grain diets (Kucuk et al., 2001; Sackmann et al., 2003; Loor et al., 2004).

No DPA or C22:6 n-3 were observed in adipose tissue samples in the current study. Adipose tissue proportions of linolenic acid were greater ($P < 0.05$) in pasture-finished than feedlot-finished steers on d 84 and 140 (Table 10). On d 28, linolenic acid tended ($P = 0.07$) to be greater in the pasture-finished than feedlot-finished steers. Proportions of linolenic acid were also considerably greater ($P < 0.05$) in ruminal fluid and serum of the pasture-finished steers, compared with the feedlot-finished steers. Linolenic acid content of adipose tissue from steers in both finishing treatments was relatively high at the beginning of the study, presumably due to the high forage content of the stockering diet. There were no differences due to sampling date in either treatment. Ruminal fluid did not reflect the effects of sampling date on adipose tissue to the same extent as serum. Ruminal fluid and adipose tissue linolenic acid were correlated (r = 0.38; $P = 0.0002$). Serum and adipose linolenic acid were more strongly correlated (r = 0.56; $P < 0.0001$). Therefore, changes in adipose tissue content of linolenic acid may be indicated better by the changes in serum than ruminal fluid.

With regard to fatty acid families in adipose tissue, there were no differences due to treatment in total adipose tissue SFA or CR-SFA (Table 11). Realini et al. (2004) also observed no difference in total SFA as a result of pasture- or grain-finishing. In contrast, French et al. (2000) observed an 11% decrease in total SFA in intramuscular adipose tissue (reported as g/100 g of fatty acid methyl esters) as a result of pasture finishing, compared with cattle finished on a high-grain diet. Duckett et al. (1993) observed fluctuations in SFA over time in cattle fed a high-grain diet.

In the present experiment, there were no treatment effects on total MUFA. Similar results were observed by French et al. (2000). In contrast, Realini et al. (2004) observed a 12% increase in MUFA (reported as % of total fatty acids from intramuscular fat) as a result of grain finishing, compared with pasture finishing. In the present study, with regard to sampling date, MUFA values on d 0 within both treatments were less ($P < 0.05$) than on d 28 and 140, and d 28 was less ($P < 0.05$) than d 84 within the feedlot treatment. The results seen may have been affected by differences in the rumen environment, microbial populations, and rates of fatty acid biohydrogenation as influenced by diet.

French et al. (2000) and Realini et al. (2004) observed increased PUFA (reported as g/100 g of fatty acid methyl esters) as a result of pasture-finishing, compared with grain finishing (by 8 and 40%, respectively). In the current study, total PUFA was not affected by sampling date. Duckett et al. (1993) also observed a

Table 11. The effect of feedlot or pasture finishing treatments on fatty acid families and ratios in subcutaneous adipose tissue

	Day of study										
	Feedlot finishing treatment				Pasture finishing treatment				Effect		
Fatty acid[1]	0	28	84	140	0	28	84	140	Treatment	Date	Interaction
SFA	56.3[bef]	51.9[c]	46.6	44.9	56.3[bf]	52.1	51.7	50.7	0.09	<0.001	0.01
	(1.3)	(1.3)	(1.5)	(1.4)	(1.3)	(1.3)	(1.5)	(1.4)			
CR-SFA[2]	37.0	37.9	34.7	35.0	38.5[bef]	33.1	32.8	33.6	0.15	0.01	0.002
	(1.0)	(1.1)	(1.2)	(1.0)	(1.0)	(1.1)	(1.2)	(1.0)			
MUFA	41.1[bef]	46.1[c]	51.5	53.2	41.1[bf]	44.9	45.6	46.7	0.05	<0.001	0.01
	(1.3)	(1.3)	(1.5)	(1.4)	(1.3)	(1.3)	(1.5)	(1.4)			
PUFA	2.52	1.99	1.95	1.96	2.62	2.92	2.69	2.63	0.03	0.29	0.07
	(0.29)	(0.21)	(0.17)	(0.19)	(0.29)	(0.21)	(0.17)	(0.19)			
PUFA:SFA ratio	0.045	0.039	0.042	0.044	0.047	0.057	0.052	0.052	0.07	0.91	0.03
	(0.0053)	(0.0043)	(0.0032)	(0.0041)	(0.0053)	(0.0043)	(0.0032)	(0.0041)			
PUFA:CR-SFA ratio	0.068	0.053[a]	0.057[a]	0.056	0.067	0.090	0.082	0.079	0.01	0.76	0.01
	(0.0070)	(0.0074)	(0.0050)	(0.0061)	(0.0070)	(0.0074)	(0.0050)	(0.0061)			
n-6:n-3 ratio	1.28[bef]	1.94[ac]	4.28[ad]	5.16[a]	1.20	1.00	1.03	0.87	<0.001	<0.001	<0.001
	(0.14)	(0.18)	(0.45)	(0.53)	(0.12)	(0.16)	(0.43)	(0.50)			

[a]Within date, feedlot and pasture finishing treatments differ ($P < 0.05$).
[b]Contrast: within treatment, d 0 and 28 differ ($P < 0.05$).
[c]Contrast: within treatment, d 28 and 84 differ ($P < 0.05$).
[d]Contrast: within treatment, d 84 and 140 differ ($P < 0.05$).
[e]Contrast: within treatment, d 0 and 84 differ ($P < 0.05$).
[f]Contrast: within treatment, d 0 and 140 differ ($P < 0.05$).
[1]The data are expressed as the percentage of the total fatty acids quantified and are reported as least squares means (±SEM).
[2]CR-SFA = cholesterol raising SFA (sum of SFA, excluding 18:0).

gradual decrease in PUFA in cattle resulting from feeding a high-grain diet.

There was no treatment effect on the ratios of total PUFA:SFA. However, the ratios of total PUFA:CR-SFA were less ($P < 0.05$) in the adipose tissue from feedlot-finished steers than pasture-finished steers on d 28 and 84 (Table 11). The decreased PUFA:CR-SFA ratios indicate that perhaps a less healthy final product would be produced from the feedlot-finished beef, compared with pasture-finished beef, because it would contain less PUFA and more CR-SFA.

The feedlot-finished steers contained greater ($P < 0.05$) ratios of n-6:n-3 in adipose tissue obtained on d 28, 84, and 140, as compared with pasture-finished steers. Within the feedlot finishing treatment, n-6:n-3 ratios increased ($P < 0.05$) throughout the study. These ratios indicate that pasture-finished beef may provide more n-3, and subsequently less n-6, fatty acids to consumers. French et al. (2000) and Realini et al. (2004) observed 44 and 52%, respectively, greater n-6:n-3 in intramuscular fat from grain-finished cattle, compared with pasture-finished cattle.

In general, cattle do not have to be on a diet for very long for changes in fatty acids in adipose tissue to be evident. By d 28, the *cis*-9, *trans*-11 CLA and linolenic acid concentrations within adipose tissue in the feedlot-finished cattle had decreased by 31%, respectively. Further reductions were observed until d 84. Within the pasture-finished cattle, concentrations of *cis*-9, *trans*-11 CLA, and linolenic acid remained elevated throughout the study. Therefore, cattle do not have to be on grain-based diets for very long for reductions in *cis*-9, *trans*-11 CLA and linolenic acid in adipose tissue to occur.

The lack of differences between initial and subsequent sampling dates within the pasture finishing treatment for *cis*-9, *trans*-11 CLA and linolenic acid may be attributed to the forage-based stockering diet. Although the stockering diets consisted of up to 34.5% soybean hulls, the soybean hulls were high in fiber (60.7% NDF). Therefore, the high-fiber content of the stockering diet may have been similar to the pasture finishing system such that large changes in *cis*-9, *trans*-11 CLA did not occur. In the current study, *trans*-vaccenic acid, *cis*-9, *trans*-11 CLA, and linolenic acid concentrations in ruminal fluid were relatively high at the beginning of the study, leading to relatively high concentrations of these fatty acids in adipose tissue.

Based on the significant correlations observed in the current study, ruminal fluid or serum may be used as an indicator of *trans*-vaccenic acid, *cis*-9, *trans*-11 CLA, and linolenic acid proportions in adipose tissue. Ruminal fluid and serum samples can be collected relatively easily and are less invasive than subcutaneous adipose tissue or muscle biopsies. Along with biopsies, ruminal fluid and serum samples can be collected over time during finishing, so cattle do not have to be slaughtered at intervals throughout the study to evaluate changes in fatty acids resulting from time on feed. This allows the same number of animals to be maintained throughout the study, and individual animal variation can be taken into consideration. However, due to inconsistencies among ruminal fluid, serum, and adipose SFA and MUFA, caution should be used if evaluating these fatty acids.

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